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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

03300245.2

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For the President of the European Patent Office

Le Président de l'Office européen des brevets
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R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Method and system for controlling the level of a data signal read from an optical disc

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"Method and system for controlling the level of a data signal read from an optical disc"

FIELD OF THE INVENTION

The present invention relates to a method and system for controlling the level of a data signal read from an optical disc.

The present invention also relates to a method of generating an information signal intended to indicate the presence of a defect at the surface of an optical disc.

This invention has many applications in the field of optical recording.

BACKGROUND OF THE INVENTION

In optical recording systems such as CD, DVD, or Blue Ray (BD) disc, the information recorded on the optical disc is retrieved from a readout signal, conventionally represented by an eye pattern as illustrated in Fig.1. Information is often retrieved from a processing chain including a photo detector, a bit detection system, a preamplifier, a gain and level control, an equalizer, a timing recovery system and error correction system.

Data information is for example recorded on the disc by a series of pits and lands representing binary data, and forming a track. A laser spot remains locked to the track for passing-by the pit-land relief structure. The reflected light spot falls onto the photo-detector. The regions between the impressed pits reflect the incident light without destructive interference and hence, the corresponding readout signal derived from the photo detector reaches maximum values. Conversely, a minimum level of the readout signal corresponds to a light which is strongly reduced by interference while reflected by a pit. The readout signal as depicted in Fig.1, referenced by the dark level (DL), is thus spatially modulated by the pits and lands, which are integer multiples of the channel bits.

For ensuring a robust reading of the data stored on the disc, it is required to generate a readout signal varying between a low target level I_min_target and a high target level I_max_target, these targets levels being known from specifications or from a measurement.

Gain and level control are dedicated to bring the readout signal in an appropriate range, in particular by counteracting level variations due to a reduction of the disc reflectivity caused by a defect of the disc, such as a fingerprint, a scratch or a black dot.

Known gain and level control systems are based on combinations of peak detection and time constants. In such systems, gain is increased until a predefined peak level is exceeded. When this happens, gain is decreased again. A similar approach is used for level control. The gain and level adaptation is commonly done in using a time constant. When the time constant is large, the system response is slow but accurate in the nominal situation, as the gain and level control signals are usually not very noisy. On the other hand, a slow response prevents the system from quickly responding to defects. If the time constant is reduced, the system becomes jittery, thus degrading the performance which is measured in terms of jitter and error rate. The optimum setting is dependent on many parameters in drive and disc, and usually determined by trail and error.

This known method is limitative in that the optimal time constant is difficult to define, considering that it should be large to prevent baseline wander, but small to effectively remove undesired low-frequency variations due to disc defects.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to propose an improved method of controlling the level of an input readout signal read from an optical disc.

To this end, the method according to the invention proposes to use an amplification step for amplifying the input readout signal by a adjustable gain, for generating an amplified output readout signal having an amplitude in the range [I_min_target, I_max_target]. The value of this gain is derived from a feed-back loop control in charge of comparing the level of the output readout signal to that of target levels I_min_target and I_max_target, and deriving a gain value taking into account the level of the input readout signal. This loop control allows to perform a clamping of the input readout signal, counteracting as a consequence the decrease of the input readout signal in case of a reflectivity reduction of the optical disc.

The method is based on the fact that the outer levels of the input readout signal reduce in similar way with respect to the dark level, because reflectivity of pit and land is deteriorated in equal way by the aforementioned defects of the optical disc. Thus, there is only one parameter to adjust, this parameter being the gain with respect to the dark level.

This method is also relevant in that the level control is independent of the frequency content of the readout signal because the control is only based on amplitude information.

It is also an object of the invention to propose a control system for controlling the level of an input readout signal, said control system comprising means for implementing the different steps of the above-mentioned method according to the invention.

In case of an important defect, such as a black dot or a deep scratch, the reflectivity of the laser beam is highly reduced. As a consequence, the input readout signal is of small amplitude and very noisy, so that it can be assumed that even if setting the gain to a very high value, data recovery is in this case nearly impossible.

An additionnal step is thus advantageously added to the above-mentioned method according to the invention. This additionnal step consists in a step of generating a signal being intended to take a first state if said gain is below a gain threshold, and a second state if said gain is above said gain threshold.

This information signal is used for indicating the presence of a defect at the surface of an optical disc resulting in a reflectivity reduction. This information signal may for example be used to improve the reading strategy of the optical disc, for example in jumping the area considered as comprising a defect.

Detailed explanations and other aspects of the invention will be given below.

BRIEF DESCRIPTION OF THE DRAWINGS

The particular aspects of the invention will now be explained with reference to the embodiments described hereinafter and considered in connection with the accompanying drawings, in which identical parts or sub-steps are designated in the same manner :

Fig.1 illustrates the eye pattern of a input readout signal read from an optical disc,

Fig.2 represents the flow chart of processing steps according to the invention,

Fig.3 represents an embodiment of a control system according to the invention,

Fig.4 illustrates by an example the method according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig.2 represents the flow chart of processing steps for controlling the level of an input readout signal S_in read from an optical disc, for generating an output readout signal S_out.

This method comprises a step 101 of amplifying the input readout signal S_in by a gain G for generating the output readout signal S_out. Readout signals are thus linked by the following relation :

$$S\_out = G * S\_in \qquad \text{Eq.1}$$

The gain G is initially set to an arbitrary value G0, for example G0 = 1.

This method comprises a step 102 of comparing said output readout signal S_out with a maximum target level I_max_target and with a minimum target level I_min_target. The target levels are for example known from specifications, or chosen by measurement so as to be close to the maximum and minimum levels of the input readout signal S_in in optimal conditions (i.e. without reduction of the laser beam reflected from the optical disc).

This method comprises a first step 103 of setting said gain G to a value G1 defined as the ratio between said maximum target level I_max_target and the level of said input readout signal S_in, if the level of said output readout signal S_out exceeds said maximum target level I_max_target. This step 103 is summarized by the following first rule :

if S_out > I_max_target,
then G = G1 = I_max_target / S_in   Eq.2

By setting the gain G to a particular value G1, the step 103 results in a clipping of the readout signal to I_max_target. Consequently, the readout signal is brought to within the range [I_min_target, I_max_target].

This method comprises a second step 104 of setting said gain G to a value defined G2 as the ratio between said minimum target level I_min_target and the level of said input readout signal S_in, if the level of said output readout signal S_out drops below said

minimum target level I_min_target. This step 104 is summarized by the following second rule:

if S_out < I_min_target,
then G = G2 = I_min_target / S_in   Eq.3

By setting the gain G to a particular value G2, the step 104 results in a clipping of the readout signal to I_min_target. Consequently, the readout signal is brought to within the range [I_min_target, I_max_target].

This method comprises a third step 105 of setting said gain G to the value as previously set by said first and second steps 103 and 104 of setting, if the level of said output readout signal S_out does not exceed said maximum target level I_max_target nor drop below said minimum target level I_min_target. In other words, if the output readout signal S_out stay in the range [I_min_target, I_max_target], the gain G is not changed, and it remains either equal to the initial gain value G0, or to the gain value G1 defined by the first rule, or to the gain value G2 defined by the second rule.

Note that the procedure according to the invention of bringing the readout signal to within the range [I_min_target, I_max_target] can be executed continuously and possibly instantaneously, to track the variations in play back conditions (i.e. reflectivity changes).

The processing steps 102-103-104-105 can be the basis for defining a method of generating an information signal S_info indicating a defect of an optical disc. This method of generating an information signal is based on the variation analysis of the gain value G.

To this end, this method of generating an information signal S_info comprises a step 106 of comparing said gain G with a gain threshold G_th, and a step 107 of generating said information signal having a first state s1 if said gain G is below said gain threshold G_th, and a second state s2 if said gain G is above said gain threshold G_th.

The input readout signal can be considered as the sum of a data signal, and a noise signal of constant amplitude. If the input readout signal S_in is very low, thus mainly comprising a noise signal, a gain G having a large value is derived from step 103. Since it is no sense amplifying an input readout signal S_in mainly comprising a noise signal, because detection of data is impossible in this case, the gain threshold G_th may be defined as the

ratio I_min_target / σ, where σ corresponds to a measure of the noise level in the input readout signal S_in.

This information signal S_info may for example be used to improve the reading strategy of the optical disc, for example in jumping the area considered as comprising a defect.

Fig.3 represents an embodiment of a control system according to the invention for controlling the level of an input readout signal S_in read from an optical disc, for generating an output readout signal S_out, said system comprising :

- means 301 for amplifying said input readout signal S_in by a gain G for generating said output readout signal S_out,
- means 302 for comparing said output readout signal S_out with a maximum target level I_max_target and with a minimum target level I_min_target,
- means 302 for setting said gain G to a value defined as the ratio between said maximum target level I_max_target and the level of said input readout signal S_in, if the level of said output readout signal S_out exceeds said maximum target level I_max_target,
- means 302 for setting said gain G to a value defined as the ratio between said minimum target level I_min_target and the level of said input readout signal S_in, if the level of said output readout signal S_out drops below said minimum target level I_min_target,
- means 302 for setting said gain G to the value as previously set by said first and second means 302 for setting, if the level of said output readout signal S_out does not exceed said maximum target level I_max_target nor drop below said minimum target level I_min_target.

The processing may be performed in the digital domain. Means 302 correspond to a signal processor executing code instructions stored in a memory device (not shown). These code instructions carry out the functions realized by steps 102-103-104-105 previously described, taking into account the value of input parameters I_min_target and I_max_target for example stored in said memory device. Analogue to digital converters (not shown) are used for sending to the processing means 302 a digital value of the input readout signal S_in and the output readout signal S_out.

Means 301 may also be performed by a signal processor, or alternatively by a conventional amplifier using a transistor-based structure. In the latter case, the gain defined by means 302 is buffered in an input digital register, then converted in the analogue domain by a digital to analogue converter (not shown) for varying some gain parameters of the amplification means 301 (e.g. the charge of a capacitor by a current proportional to the analogue gain value).

Fig.4 illustrates by an example the level control performed by the method according to the invention. In this figure :

- signal S_theo corresponds to the temporal variation of the theoretical readout signal that should be derived from the reading of the optical disc, without reflectivity reduction. This signal varies in the range [I_min_target, I_max_target].
- S_in corresponds to the temporal variation of the experimental input readout signal derived from an photo detector when the optical disc is read, for example a four-quadrants detector embedded in a reader apparatus intended to read the optical disc,
- α corresponds to the temporal variation of the reflectivity attenuation caused by the defect of the optical disc, the attenuation being for example caused by a scratch, a fingerprint or a black dot at the surface of the optical disc. This attenuation is of course not known by the system control.
- S_out corresponds to the temporal variation of the output readout signal after being passed through the control system according to the invention,
- G corresponds to the temporal variation of the amplification gain applied to the input readout signal S_in for generating the output readout signal S_out.

In the temporal range [t0, t1], the reflectivity of the laser beam applied to the optical disc is not reduced since no defects are present at the surface of the optical disc. The input readout signal S_in is in the range [I_min_target, I_max_target], and the gain G is for example set to an initial default value equal to 1. The output readout signal S_out is identical to the input readout signal S_in.

In the temporal range [t1, t2], the reflectivity of the laser beam applied to the optical disc is attenuated by a factor 2, because of some defects present at the surface of the optical disc. The input readout signal S_in immediately decreases by a factor 2, but still remains in

the range [I_min_target, I_max_target], so that the gain G remains equal to 1. The output readout signal S_out is identical to the input readout signal S_in.

In the temporal range [t2, t3], the reflectivity of the laser beam applied to the optical disc is still attenuated by a factor 2. The input readout signal S_in now drops below I_min_target until reaching I_min_target / 2. The output readout signal S_out is also inclined to drop below I_min_target, but S_out is immediately corrected by the control system in increasing the gain G according to the Eq.3. The gain G increases until reaching a value of 2. The signal S_out is thus clipped to I_min_target.

In the temporal range [t3, t4], the reflectivity of the laser beam applied to the optical disc is still attenuated by a factor 2. The input readout signal S_in now starts increasing above I_min_target / 2. With a gain previously set to 2, the output readout signal S_out is now inclined to exceed I_min_target, so that S_out is still in the range [I_min_target, I_max_target]. As a consequence, the gain G applied to signal S_in remains set to the previously value defined at time t3 according to Eq.3. The signal S_out is identical to the theoretical data signal S_theo, which means that the reduction of the laser beam reflectivity is compensated by the control system according to the invention.

In the temporal range [t4, t5], the optical disc has no more defects on its surface. The laser beam is thus no more attenuated so that the attenuation gain α goes down to 1. The input readout signal S_in is now identical to signal S_theo. With a gain previously set to 2, the output readout signal S_out is now inclined to exceed I_max_target, so that S_out is immediately corrected by the control system in decreasing the gain G according to Eq.2. The gain G decreases until reaching a value of 1. The signal S_out is thus clipped to I_max_target.

In the temporal range [t5, t6], the input readout signal S_in now starts decreasing below I_max_target. With a gain previously set to 1, the output readout signal S_out is now inclined to drop below I_max_target, so that S_out is in the range [I_min_target, I_max_target]. As a consequence, the gain G applied to signal S_in remains set to the previously value defined at time t5 according to Eq.2. The signal S_out is thus identical to the input readout signal S_in and to the theoretical data signal S_theo.

It is noted that the readout signal in the temporal range [t1, t2] cannot be recovered since the input readout signal S_in is still in the range [I_min_target, I_max_target] which is considered as a correct range, as well in the temporal ranges [t2, t3] and [t4, t5] since the output readout signal S_out is clipped to I_min_target and I_max_target respectively.

In the temporal range [t0, ts1], the gain G is below the gain threshold G_th, so that the information signal S_info has a first state s1.

In the temporal range [ts1, ts2], the gain G is above the gain threshold G_th, so that the information signal S_info has a second state s2.

In the temporal range [ts2, t6], the gain G is below the gain threshold G_th, so that the information signal S_info has the first state s1.

The control system according to the invention can advantageously be implemented in an apparatus for reading data stored on an optical disc.

Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in the claims. Use of the article "a" or "an" preceding an element or step does not exclude the presence of a plurality of such elements or steps.

CLAIMS

1. Method of controlling the level of an input readout signal (S_in) read from an optical disc for generating an output readout signal (S_out), said method comprising :

- a step (101) of amplifying said input readout signal (S_in) by a gain (G) for generating said output readout signal (S_out),
- a step (102) of comparing said output readout signal (S_out) with a maximum target level (I_max_target) and with a minimum target level (I_min_target),
- a first step (103) of setting said gain (G) to a value defined as the ratio between said maximum target level (I_max_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) exceeds said maximum target level (I_max_target),
- a second step (104) of setting said gain (G) to a value defined as the ratio between said minimum target level (I_min_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) drops below said minimum target level (I_min_target),
- a third step (105) of setting said gain (G) to the value as previously set by said first and second steps (103, 104) of setting, if the level of said output readout signal (S_out) does not exceed said maximum target level (I_max_target) nor drop below said minimum target level (I_min_target).

2. Method of generating an information signal indicating a defect of an optical disc, said method comprising :

- a step (101) of amplifying an input readout signal (S_in) by a gain (G) for generating an output readout signal (S_out),
- a step (102) of comparing said output readout signal (S_out) with a maximum target level (I_max_target) and with a minimum target level (I_min_target),
- a first step (103) of setting said gain (G) to a value defined as the ratio between said maximum target level (I_max_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) exceeds said maximum target level (I_max_target),

- a second step (104) of setting said gain (G) to a value defined as the ratio between said minimum target level (I_min_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) drops below said minimum target level (I_min_target),
- a third step (105) of setting said gain (G) to the value as previously set by said first and second steps (103, 104) of setting, if the level of said output readout signal (S_out) does not exceed said maximum target level (I_max_target) nor drop below said minimum target level (I_min_target),
- a step (106) of comparing said gain (G) with a gain threshold (G_th),
- a step (107) of generating said information signal having a first state (s1) if said gain (G) is below said gain threshold (G_th), and a second state (s2) if said gain (G) is above said gain threshold (G_thr).

3. System for controlling the level of an input readout signal (S_in) read from an optical disc for generating an output readout signal (S_out), said system comprising :

- means (101) for amplifying said input readout signal (S_in) by a gain (G) for generating said output readout signal (S_out),
- means (102) for comparing said output readout signal (S_out) with a maximum target level (I_max_target) and with a minimum target level (I_min_target),
- means (103) for setting said gain (G) to a value defined as the ratio between said maximum target level (I_max_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) exceeds said maximum target level (I_max_target),
- means (104) for setting said gain (G) to a value defined as the ratio between said minimum target level (I_min_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) drops below said minimum target level (I_min_target),
- means (105) for setting said gain (G) to the value as previously set by said first and second means (103, 104) for setting, if the level of said output readout signal (S_out) does not exceed said maximum target level (I_max_target) nor drop below said minimum target level (I_min_target).

4. Apparatus for reading an optical disc, said apparatus comprising a system for controlling the level of an input readout signal (S_in) read from said optical disc for generating an output readout signal (S_out), said system comprising :

- means (101) for amplifying said input readout signal (S_in) by a gain (G) for generating said output readout signal (S_out),
- means (102) for comparing said output readout signal (S_out) with a maximum target level (I_max_target) and with a minimum target level (I_min_target),
- means (103) for setting said gain (G) to a value defined as the ratio between said maximum target level (I_max_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) exceeds said maximum target level (I_max_target),
- means (104) for setting said gain (G) to a value defined as the ratio between said minimum target level (I_min_target) and the level of said input readout signal (S_in), if the level of said output readout signal (S_out) drops below said minimum target level (I_min_target),
- means (105) for setting said gain (G) to the value as previously set by said first and second means (103, 104) for setting, if the level of said output readout signal (S_out) does not exceed said maximum target level (I_max_target) nor drop below said minimum target level (I_min_target).

5. A computer program comprising code instructions for implementing the steps of the method as claimed in claim 1 or 2.

ABSTRACT

The invention relates to a method of controlling the level of an input readout signal read from an optical disc. The method proposes to use an amplification step for amplifying the input readout signal by a adjustable gain, for generating an amplified output readout signal having an amplitude in the range [I_min_target, I_max_target]. The value of this gain is derived from a feed-back loop control in charge of comparing the level of the output readout signal to that of target levels I_min_target and I_max_target, and deriving a gain value taking into account the level of the input readout signal. This loop control allows to perform a clamping of the input readout signal, counteracting as a consequence the decrease of the input readout signal in case of a reflectivity reduction of the optical disc.

Use : Optical disc reader

Ref : Fig.3

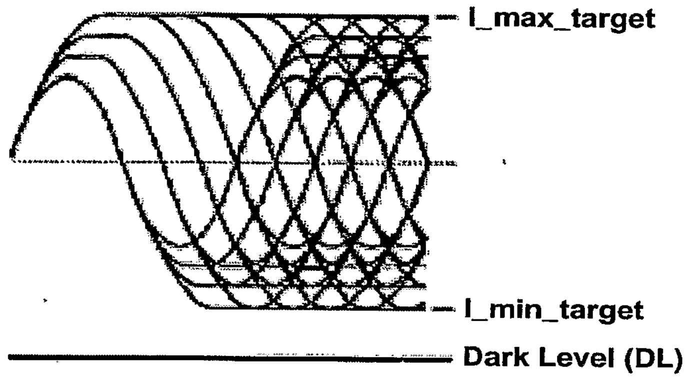


FIG.1

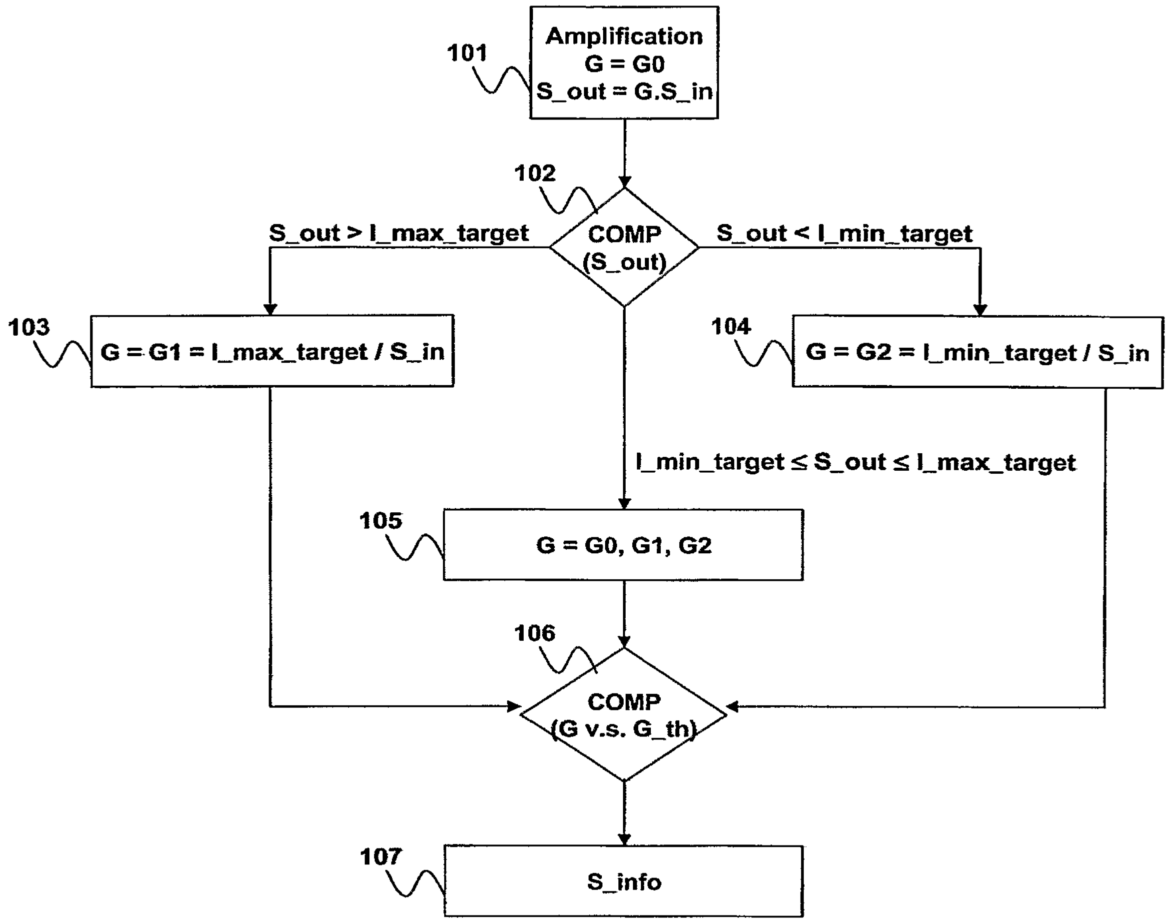

Amplification
G = G0
S_out = G.S_in
101
102
COMP
(S_out)
S_out > I_max_target
S_out < I_min_target
103
G = G1 = I_max_target / S_in
104
G = G2 = I_min_target / S_in
I_min_target ≤ S_out ≤ I_max_target
105
G = G0, G1, G2
106
COMP
(G v.s. G_th)
107
S_info

FIG.2

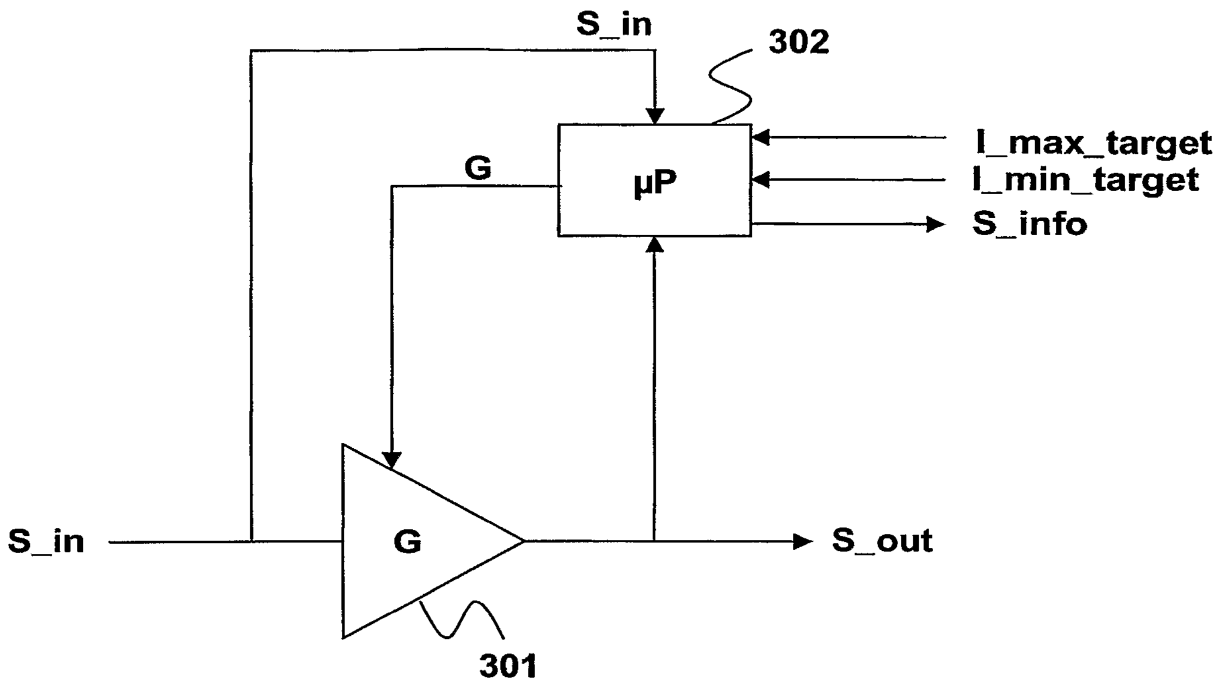
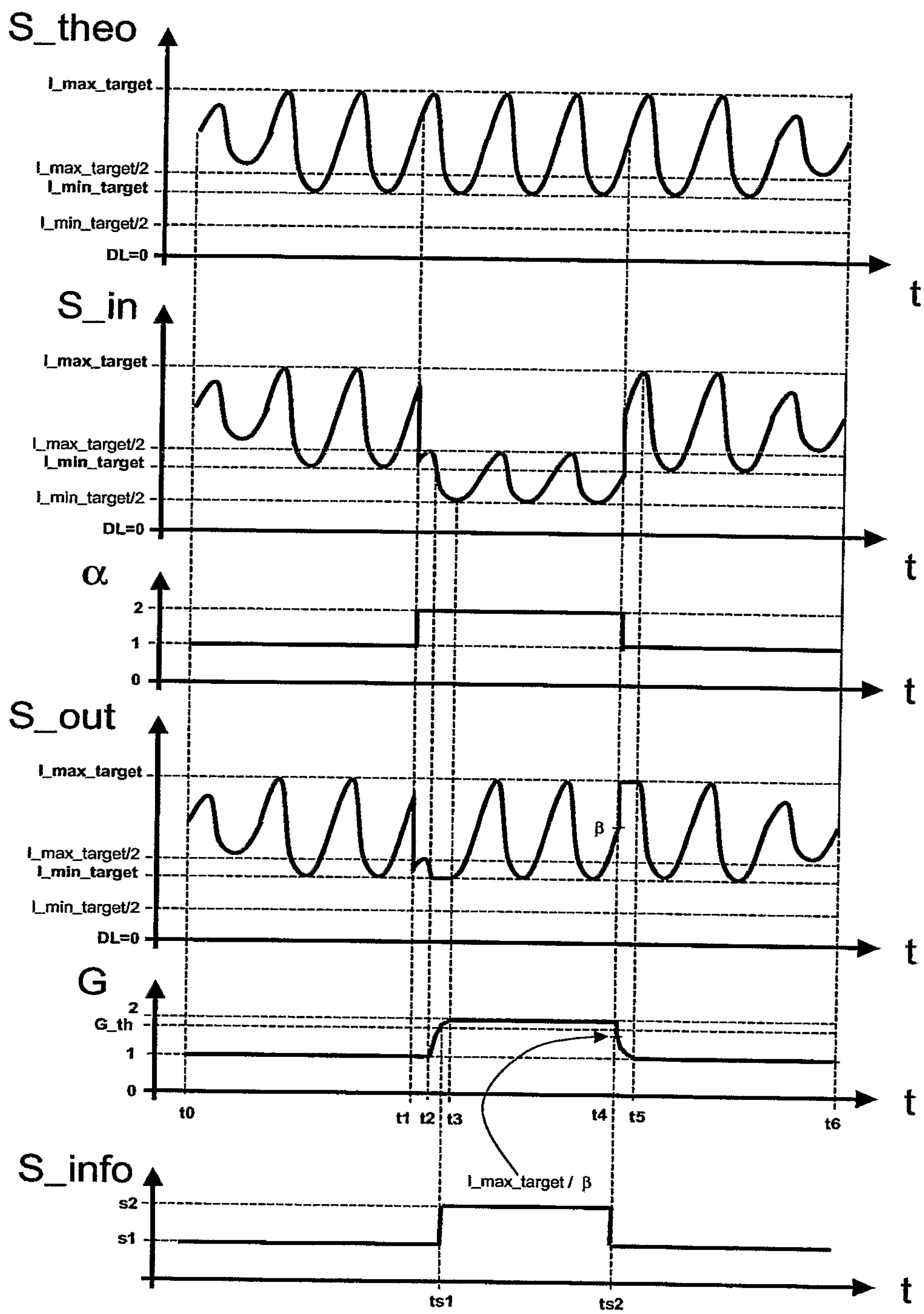


FIG.3



S_theo
I_max_target
I_max_target/2
I_min_target
I_min_target/2
DL=0
t
S_in
I_max_target
I_max_target/2
I_min_target
I_min_target/2
DL=0
t
α
2
1
0
t
S_out
I_max_target
β
I_max_target/2
I_min_target
I_min_target/2
DL=0
t
G
2
G_th
1
0
t0
t1
t2
t3
t4
t5
t6
t
S_info
I_max_target / β
s2
s1
ts1
ts2
t

FIG.4